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Patentanmeldung Nr.   **Patent application No.**   **Demande de brevet n°**

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Im Auftrag

For the President of the European Patent Office

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R C van Dijk

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(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
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A mobile communication base station apparatus and a baseband processing section

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A Mobile Communication Base Station Apparatus and a Baseband Processing Section

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Field of the Invention

The present invention relates to a mobile communication base station apparatus, in particular to a scalable W-CDMA NODE-B System, and a baseband processing section.

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Such a mobile communication base station with a radio channel setting control is e.g. known from US Patent Application No. 5,889,769. The establishment of virtual connections passing through a multi-stage switching system is known from the US Patent Application No. 4,907,220.

15

Universal Mobile Telecommunication system (UMTS) addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. The new network increases transmission speed to 2 Mbps per mobile user and establishes a global

20   roaming standard.

The main characteristics of 3G systems are: Used worldwide, Used for all mobile applications, support both packet-switched (PS) and circuit-switched (CS) data transmission, and offer high data rates up to 2 Mbps (depending

25   on mobility/velocity) and a high spectrum efficiency.

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One of the most significant changes is the new UMTS terrestrial radio access (UTRA), a wide-band code division multiple access (W-CDMA) radio interface for land-based communications. UTRA supports time division duplex (TDD) and frequency division duplex (FDD).

5

In UMTS release 1, a new radio access network UMTS terrestrial radio access network (UTRAN) is introduced, shown in figure 1. UTRAN, the UMTS radio access network (RAN), is connected via the Iu to the Global System for Mobile Communications (GSM) Phase 2+ core network (CN).

10   The 'Iu' is the UTRAN interface between the radio network controller (RNC) and CN.

Two network elements are introduced in UTRAN, RNC, and node B. UTRAN is subdivided into individual radio network systems (RNSs), where each RNS

15   is controlled by an RNC. The RNC is connected to a set of node B elements, each of which can serve one or several cells. Node B is the physical unit for radio transmission/reception with cells. Depending on sectoring, one or more cells may be served by a node B. Node B collects with the UE via th W-CDMA Uu radio interface and with the RNC via the Iub asynchronous

20   transfer mode (ATM)-based interface. Node B is the ATM termination point.

The main task of node B is the conversion of data to and from the Uu radio interface, including forward error correction (FEC), rate adaptation, W-CDMA spreading/de-spreading, and quadrature phase shift keying (QPSK)

25   modulation on the air interface.

W-CDMA can support mobile/portable voice, images, data, and video communications at up to 2 Mbps (local area access) or 384 Kbps (wide area access). The input signals are digitized and transmitted in coded,

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spread-spectrum mode over a broad range of frequencies. A 5 MHz-wide carrier is used, compared with 200 kHz-wide carrier for narrow-band CDMA.

5   CDMA uses unique spreading codes to spread the baseband data, i.e., th original band of frequencies, before transmission. The signal is transmitted in a channel, which is below noise level. The receiver then uses a correlator to de-spread the wanted signal, which is passed through a narrow band-pass filter. Unwanted signals will not be de-spread and will not pass

10   through the filter. Codes take the form of a carefully designed one/zero sequence produced at a much higher rate than that of the baseband data. The rate of a spreading code is referred to as chip rate rather than bit rate.

       W-CDMA uses Direct Sequence spreading, where spreading process is

15   done by directly combining the baseband information to high chip rate binary code. The Spreading Factor is the ratio of the chips (UMTS = 3.84Mchips/s) to baseband information rate. Spreading factors vary from 4 to 512 in FDD UMTS.

20   As illustrated above through multiple UMTS requirements the major challenge is the tight adaptation of the radio transmitter on the data streams to be transmitted. The encoding and decoding according to W-CDMA requires a tight connection between radio transmitters and data stream construction and reconstruction, performed by baseband processor

25   sections.

       To cope with UMTS requirements as well as scalability and robustness of e.g. a node B, an efficient architectural design is necessary in order to

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implement compliant and performant node B, i.e., to d fine functional
entities and their interaction.

5   This invention has the underlying problem of designing a scalable and
robust base station, especially a W-CDMA node B system, with non-critical
components, avoiding e.g. critical line length matching.

The problem is solved by a mobile communication base station apparatus
comprising a plurality of radio transmission and/or reception sections and
10   a plurality of baseband processing sections, such that the plurality of
baseband processing sections are divided into stages, arranged in at least
two consecutive stages, where each stage each comprising multiple
baseband processing sections, the radio transmission and/or reception
sections are connected to a first stage of the baseband processing sections
15   and other stages of the baseband processing sections are multistage-
connected to the first stage of the baseband processing sections so that the
baseband processing sections form a stage configuration of consecutive
interconnected stages of baseband processing sections, where each
baseband processing section comprises adding means, dropping means,
20   and routing means for extraction and injection of data streams and routing
the data streams through the stages. The mobile communication base
station apparatus might be a W-CDMA NODE-B System and the adding
and dropping means controlling the spreading and de-spreading according
to code division multiple access. The transmission and/or reception sections
25   might be decomposed into receiver modules and transmitter modules. And
the baseband processing sections within one stage might be interconnected.
The stage configuration is preferably a matrix configuration and the
number of baseband processing sections in the stages of the baseband
processing sections is constant. Said routing means might support load

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balancing on said interfaces by using corr sponding interface conn ctions. The mobile communication base station apparatus might comprising detection means for detecting defect baseband processing sections and said routing means might support fault tolerance by using routing paths

5   avoiding said defect baseband processing sections.

The problem is further solved by a baseband processing section for use in a mobile communication base station apparatus, comprising a baseband-processing-section-to-baseband processing section interface for data

10 streams transmitted and/or received between the baseband processing section and another baseband processing section, adding means for injecting additional data streams to received data stream, dropping means for extracting data streams from received data streams, and routing means for passing resulting data streams over said interface. The baseband

15 processing section might comprising adding and dropping means controlling the spreading and de-spreading according to code division multiple access. And the baseband processing section might comprising baseband-processing-section-to-transmission-and/or-reception-sections-interface for data streams transmitted and/or received between the

20 baseband processing section and transmission and/or reception sections.

In other words, as mentioned above the main functionality of a node B is to perform the air interface processing, i.e. channel coding and interleaving, rate adaptation, spreading, etc. Major components are radio transmitter

25 sections responsible for receiving and transmitting the radio signal, i.e. generating (power amplifier) and receiving (receiver) by modulating (filter) and demodulating (filter) carriers. A second functional component are baseband processors, encoding and decoding, multiplexing and de-multiplexing W-CDMA signals.

6

Full interface matrix configuration, shown in figure 5, is generally used, allowing multiple baseband processors to connect to one radio transmitter. However its implementation is of higher cost and complicated, e.g. with

5   respect to critical line length matching. Huge, non-standard size back-planes, e.g. one backplane for two sub-racks, with critical line length matching are required. In addition both receiver and sender functions are split and realized by two separate sections, like a power amplifier and up-converter for a sender unit.

10

A scalable stage matrix interface configuration is proposed, using a comparable small backplane and cables to connect the sender and rec iver sections with the baseband processors sections. By this it becomes possible to realize up-converter and power amplifier as one module and also to

15   combine diplexer filter and down-converter in one module, as well as avoiding the critical line length matching interface between baseband processors and radio transmitter.

Several baseband processors modules are grouped into stages. The

20   baseband processors aggregating board data and stage-to-stage data streams, allowing a smooth adding and dropping of data streams and a balanced routing through the proposed stage connection network.

The first stage serves the radio transmitters and radio receivers. This system

25   decomposition avoid critical line length matching and could be realized using passive components and standard back-plane with non critical line length matching, and Cat-5 cable, i.e. 100 ohm unshielded twisted pair UTP cables characterized to 100 MHz, supporting applications up to 100 Mbps.

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The stage interfac could for instance consist of stages holding 3 baseband
modules. The first stage is interfacing to the radio transmitter. Each stag is
interconnected to the next stage by a complete mesh. Preferably, in addition
5   to these interfaces, the baseband processing sections in the first stage are
interconnected via inter-stage interface. Baseband processors in the
following stages have stage-to-stage interfaces to the preceding stage and
to the succeeding stage. A radio transmitter might select among three int r-
connections to connect the first stage. Hence, instead full-matrix interface
10   configuration between radio transmitter and baseband processors, the
functionality is distributed over the multistage-connected baseband
processing sections.

Accordingly, it is an object and advantage of the present invention to
15   provide an scalable base station apparatus, in particular to a scalable W-
CDMA NODE-B System, with baseband modules interfacing to radio-
transmitter modules avoiding wiring concentration and critical line length
matching. This yields e.g. to simplification of mother boards and small
equipment size, and enables a compact and clear design, e.g. one section
20   for each radio transceiver and radio transmitter functionality and a
reduction back-plane board complexity.

Another advantage of the present invention is that the invention provides an
base station apparatus with non-critical interfaces between baseband
25   processors and radio unit which is flexible scalable.

A further advantage of the present invention is that the base station cold be
implemented using low cost standard components.

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Yet another advantage of the present inv ntion is the enhanced flexibility, scalability, and robustness of a bas   station apparatus due to robust and mature standard components. The design allows redundancy mechanisms increasing the maturity and robustness.

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These and many other objects and advantages of the present invention will become apparent to those of ordinary skill in the art from a consideration of the drawings and ensuing description.

10   **Figure. 1** is a schematic drawing of a part of a prior art UMTS terrestrial radio access network.

Figure. 2 is a schematic drawing of components of a mobile communication base station apparatus according to the invention.

15

Figure. 3 is a schematic drawing of the physical implementation of the baseband processing section radio transmitter interface of a mobile communication base station apparatus according to the invention.

20   **Figure. 4** is a schematic drawing of a preferred baseband processing section radio transmitter interface matrix configuration in a mobile communication base station apparatus according to the invention.

Figure. 5 is a schematic drawing of conventional example baseband
25   processing section radio transmitter interface of a mobile communication base station according to prior art.

Figure. 6 is a schematic drawing of baseband processing section according to the invention.

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Figur . 7 to **Figur 12** ar schematic drawings of variants of bas band processing section radio transmitter interface configurations of a mobile communication base station according to the invention.

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Figure. 1 shows a part of a prior art UMTS terrestrial radio access network 10, comprising node Bs 1,2,3, and RNCs 4,5. The node Bs are have associated antennas, forming one end of the user equipment air interfac Uu 6. Node Bs 1, 2, 3 are interconnected with RNCs 4, 5 via the IuB

10   interface 7, and the RNCs 4, 5 are interconnected via the Iur interface 8. The RNCs 4, 5 interfacing the core network via the Iu interface 9. The figure illustrates as decried in the introductory part the role of a node B as mediating element between air interface Uu 6 and the RNC interface Iub 7.

15   **Figure. 2** illustrates components of a mobile communication base station, comprising interfaces 12, 13 between (internal) components 14, as well as external interfaces 11. The shown node B comprises the following components 14: a connection area BTS CA / XIOB, a station unit modul universal SUMU, baseband boards BB, a transition adapter board TRAB, an

20   antenna receiver unit ANRU, and transmitter equipment for UMTS TEU. The external interfaces 11comprising, e.g. a BTS man machine interface BTS_MMI Eth, and BTS_MMI V24, as well as XIO, XBXB XCLK XGPS, XRT, IUB, and XPS, etc.

25   A back plane interface 12 comprises a base station control bus BCB, a physical internal addressing bus ADR, a base station internal interface BBII, an internal data clock CLKI, and baseband board to baseband board interfaces BBI.

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A second Interface 13 between baseband boards BB and antenna receiver unit ANRU, as well as transmitter equipment for UMTS TEU, via the transition adapter board TRAB, comprising a radio synchronization interface RSI, a baseband transmitter interface BTI, and a baseband

5   receiver interface BRI.

The digital internal interfaces of this NodeB are based on e.g. synchronous serial buses. The clocks and frame signals are distributed as buses to the baseband boards BB and as point-to-point connections to antenna receiver

10   unit ANRU, as well as transmitter equipment for UMTS TEU . This essential component interface is realized according to the invention.

Figure. 3 illustrates the physical realization of the baseband processing section to transmission and reception section. The figure shows baseband

15   boards BBs, transceiver boards TRs (an abstraction from the antenna receiver unit ANRU, as well as transmitter equipment for UMTS TEU in the figure 2.), the transition adapter board TRAB, and a backplane board PLA realizing the backplane interface(s) 12.

20   The baseband boards BB are interconnected and are connected with the transition adapter board TRAB via a back plane board PLA. The transition adapter board TRAB is wired by cables CABs with the transceiver boards TRs, realizing the second interface(s) 13.

25   The figure illustrates by showing the connection components, namely cables CABs and a backplane board PLA the de-coupling of the radio part and th baseband processing part in this node B construction.

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Figure. 4 shows the preferred r alization of the bas band processing
section and transmission and r ception section configuration. Th re ar
transmission and/or reception sections 20 and baseband processing
sections 21. The transmission and/or reception sections are grouped into a
5   transceiver stage 18 of three sections. The baseband processing sections
are grouped into a first stage 16 and into further stages 17, each
comprising three baseband processing sections 21, except the last one. The
consecutive first and the further stages 16, 17 are meshed, preferably by a
complete mesh. The baseband processing sections in the first stage 16 are
10   interconnected, too. And the first stage 16 is meshed with the transceiver
stage 18.

Figure. 5 shows a conventional prior art example of a mobile
communication base station apparatus. A plurality 23 of baseband boards
15   (BBX) 25 which perform signal processing for respective user terminals in
the mobile communication base station are connected to a further plurality
22 of complex radio transmission and reception sections (TRX) 22, so as to
form complete bipartite graph of N x M connections 24. Though the
configuration allows signal relief under simple control at a board failur
20   time, it is necessary to set a wiring density between TRX 26 and BPX 25 to
be high and preliminarily prepare adders or the like so as to correspond to
the number of BPs to be added on. When the number of BPs is limited,
efficiency is reduced. Hence, a configuration with lower wiring density
between TRs and BPs provides a better scalability and extensibility.
25

Comparing the design shown in figure 4 with the prior art shown in figure
5, baseband processing sections are configured in a matrix of m (columns;
stage) x n (rows) in connection between transmitter and receiver sections 20
and baseband processing sections 21. In order to allow such a stag

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configuration, a routing and addition processing function is provided in the
baseband processing sections 21.

An extension of baseband processing sections 21 is performed by
5   additional rows. In this case, in order to achieve sector-free and carrier-fre
configuration, connection between transmitter and receiver sections and the
first stage 16 of baseband processing sections 21 may be a complete mesh
connection or inter-connection may be made between the baseband
processing sections in the first stage 16. Further, for decentralizing an
10   amount of signal transmission between baseband processing sections, a full
mesh connection 19 can be made between first and further stages 16, 17.
Furthermore, for reducing the number of signals between transmitter and
receiver sections 20 and the baseband processing sections 21 in the first
stage 16, the transmitter and receiver sections 20 may be configured in a
15   matrix, too. Further, at a time of baseband processing section failure or at
a time of maintenance, the sections may have a rerouting capabilities for
relieving a route for the failed section.

Accordingly wiring concentration can be avoided, and since the number of
20   input ports of transmitter and receiver sections is fixed, extensibility is
improved.

Figure 6. shows a single baseband processing section 38, the m-th
baseband processing section 38 in the n-th stage with an user data stream
25   interface 39. The baseband processing section 38 comprises two routing
and add/drop units 31, 32, several baseband processing units 33 and
input and output interfaces 34, ..., 37.

13

Th upper input interface 35 together with the upper output interface 34
and the upper routing and add/drop unit 31 support a data stream form
left to right, i.e. coming from the n-1 th baseband processor section stage
or from the transition and receiving section, to the n+1 baseband

5   processor section stage. Correspondingly the lower input interface 37
together with the lower output interface 36 and the lower routing and
add/drop unit 32 support a data stream form left to right, i.e. coming from
the n+1 th baseband processor section stage to the n-1 baseband
processor section stage or to the transition and receiving section. Inter-stage

10   connections might be supported analogously.

The routing and add/drop units 31, 32 are capable of injecting baseband
data resulting from baseband processing units 33. Correspondingly, the
routing and add/drop units 31, 32 are capable of extracting data streams

15   for the baseband processing units 33. Further the routing and add/drop
units 31, 32 are passing the resulting data streams.

The routing might be controlled for invalidating a signal processing
performed by a failure or fault baseband processing section 35 or

20   baseband processing unit 33 or even a transmitter and/or receiving section
or a baseband processing section 38 to be subjected to maintenance (at a
failure or fault time, or reconfiguration). The control might even support a
reallocation of associated users for fault tolerance reasons.

25   Further the routing is controlled in order to balance load or to cope with
additional constraints, e.g. timing and synchronization.

Figure. 7 shows when the number of transmitter and receiver sections 20
is three. Nine baseband processing sections 21 ar stag -wis configur d,

14

three in one stage 17, i.e., [3] x [3,3,3]. Adding further stages 17 of additional baseband processing sections 21 does not influence the number of connections between baseband processing sections 21 and transmitter and receiver sections 20, since the additional sections are connected in a

5   multistage manner, as shown with a dotted lines. As illustrated, by handling baseband processing sections 21 as a stage of a vertical line, connection between transmitter and receiver sections 20 and baseband processing sections 21 can be achieved by only connection 19 to the first stage 16. Further, by multistage-connecting stages in a horizontal line,

10   extension is made possible.

Figure. 8 shows another interface configuration, [6]x[3,3,3]. Though the number of transmitter and receiver sections 20 in the transceiver stage 18

15   might be greater than the number of interfacing baseband processing sections 21 in the first stage 16, e.g. for safety reasons.

Figure. 9 shows a further interface configuration. In order to allow transmission/reception sector-free or carrier-free base station

20   configurations, the signals between all baseband processing sections 21 and all transmitter and receiver sections 20, the baseband processing sections 21 in the first stage 16 are inter-connected. Hence there are paths between every baseband processing section 21 and every transmitter and receiver section 20.

25

Figure. 10 shows an alternative interface configuration to the interface configuration shown in figure 9. Connection between transmitter and receiver sections 20 and baseband processing sections 21 in the first stage 16 of is implemented by a complete mesh 19. Hence there ar also paths

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between every baseband processing section 21 and v ry transmitter and
receiver s ction 20.

Figure. 11 shows an interface configuration with complete mesh
5   connections between baseband processing section 21 in successive stage is
performed for a similar purpose. In this case, though an amount of signal
transmission between baseband processing section 21 in the first stage 16
increases, baseband processing section to baseband processing section
connection can be made in each stage sequent to stage in order to avoid
10   concentration. The connections 19 further support additional redundancy
for re-routing over alternative paths.

The complete mesh between stages of baseband processing sections allows
to decentralize or distribute the amount of signal transmission. Furthermore
15   additional interfacing sections for the transmitter and receiver sections are
added.

Figure. 12 shows a more complex configuration, namely [2,3]x[3,4,2,1],
comprising of a first transmitter stage 18b, and a second and last
20   transceiver stage 18a, as well as a first baseband processing section stage
16a, a second one stage 17a, a third stage 17b, and a fourth stage 17c
forming. Although not necessary, the connections 19 are complete meshes.

The configuration comprises multi-staged transmitter and receiver sections
25   20, transmitter and receiver sections side employs a complex configuration,
too, in order to avoid that the number of the matrix connections between
transmitter and receiver sections 20 and the first stage 16a of baseband
processing section 21 becomes vast. Thereby, it becomes possible to
reduce the number connections and a load balancing between transmitter

16

and receiver sections 20 and baseband proc ssing section 21 as well as a load balancing for both sides.

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Claims

5   What is claimed is

1. A mobile communication base station apparatus comprising a plurality of
   radio transmission and/or reception sections (20) and a plurality of
   baseband processing sections (21, 38) comprising a user data stream

10   interface (39), **characterized in that**
   - the plurality of baseband processing sections (21, 38) is divided into
     stages (16, 16a, 17, 17a, 17b, 17c), arranged in a first stage (16, 16a)
     and further stages (17, 17a, 17b, 17c),
   - each stage (16, 16a, 17, 17a, 17b, 17c) comprising at least one

15   baseband processing section (21, 38), and
   - each baseband processing section (21, 38) of the further stages (17,
     17a, 17b, 17c) is connected with at least one baseband processing unit
     (21, 38) in any preceding stage, such that the baseband processing
     sections (21, 38) are multistage-connected to the first stage (16, 16a) of

20   the baseband processing sections (21),
   - each radio transmission and/or reception section (20) is connected to at
     least one baseband processing section (21, 38), and
   - each baseband processing section (21) comprises adding means (31,
     32), dropping means (31, 32), and/or routing means (31, 32) for

25   extraction and injection of baseband data streams and, respectively
     routing the data streams through the stages (16, 16a, 17, 17a, 17b,
     17c).

2

2. Th mobile communication base station apparatus according to claim 1, characterized in that the base station is a W-CDMA NODE-B System and the adding and dropping means (31, 32) controlling the spreading and de-spreading according to code division multiple access.

5

3. The mobile communication base station apparatus according to claim 1, characterized in that the transmission and/or reception sections are decomposed into receiver modules and transmitter modules.

10   4. The mobile communication base station apparatus according to claim 1, characterized in that baseband processing sections within one stage (16a) are interconnected.

5. The mobile communication base station apparatus according to claim 1,
15   characterized in that the stage configuration is a matrix configuration and the number of baseband processing sections in the stages of the baseband processing sections is constant (figure 11).

6. The mobile communication base station apparatus according to claim 1,
20   characterized in that said routing means (31, 32) support load balancing on said interfaces by using corresponding interface connections.

7. The mobile communication base station apparatus according to claim 1, characterized by comprising detection means for detecting defect
25   baseband processing sections and said routing means (31, 32) support fault tolerance by using routing paths avoiding said defect baseband processing sections.

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8. A baseband processing section (21, 38) for use in a mobile
    communication base station apparatus, said baseband processing section
    (21, 38) comprising an interface (39) for user data streams and being

5   **characterized by** comprising a baseband-processing-section-to-
         baseband processing section interface (27, 28, 29, 30) for data streams
         transmitted and/or received between the baseband processing section (21,
         38) and one other baseband processing section (21, 38), adding means
         (31, 32) for injecting additional data streams to received data stream,

10   dropping means (31, 32) for extracting data streams from received data
         streams, and routing means (31, 32) for passing resulting data streams
         over said baseband-processing-section-to-baseband processing section
         interface (27, 28, 29, 30).

15 9. The baseband processing section for use in a mobile communication base
        station apparatus, characterized by comprising adding and dropping
        means (31, 32) controlling the spreading and de-spreading according to
        code division multiple access.

20 10. The baseband processing section for use in a mobile communication base
        station apparatus, characterized by comprising baseband-processing-
        section-to-transmission-and/or-reception-sections-interface for data
        streams transmitted and/or received between the baseband processing
        section (19) and transmission and/or reception sections (20).

25

1

Abstract

The present invention relates to a mobile communication base station apparatus comprising a plurality of radio transmission and/or reception sections (20) and a plurality of baseband processing sections (21)

5   comprising a user data stream interface, such that the plurality of baseband processing sections (21) is divided into stages (16a, 17a, 17b, 17c), arranged in a first stage (16, 16a) and further stages (17, 17a, 17b, 17c), where each stage (16a, 17a, 17b, 17c) comprising at least one baseband processing section (21), and each baseband processing section (21, 38) of

10   the further stages (17a, 17b, 17c) is connected with at least one baseband processing unit (21) in any preceding stage, such that the baseband processing sections (21) are multistage-connected to the first stage (16a) of the baseband processing sections (21), the radio transmission and/or reception sections (20) are connected to baseband processing sections (21),

15   and where each baseband processing section (21) comprises adding means, dropping means, and/or routing means for extraction and injection of baseband data streams and/or routing the data streams through the stages (16a, 17a, 17b, 17c). The invention further relates to a baseband processing section (21).

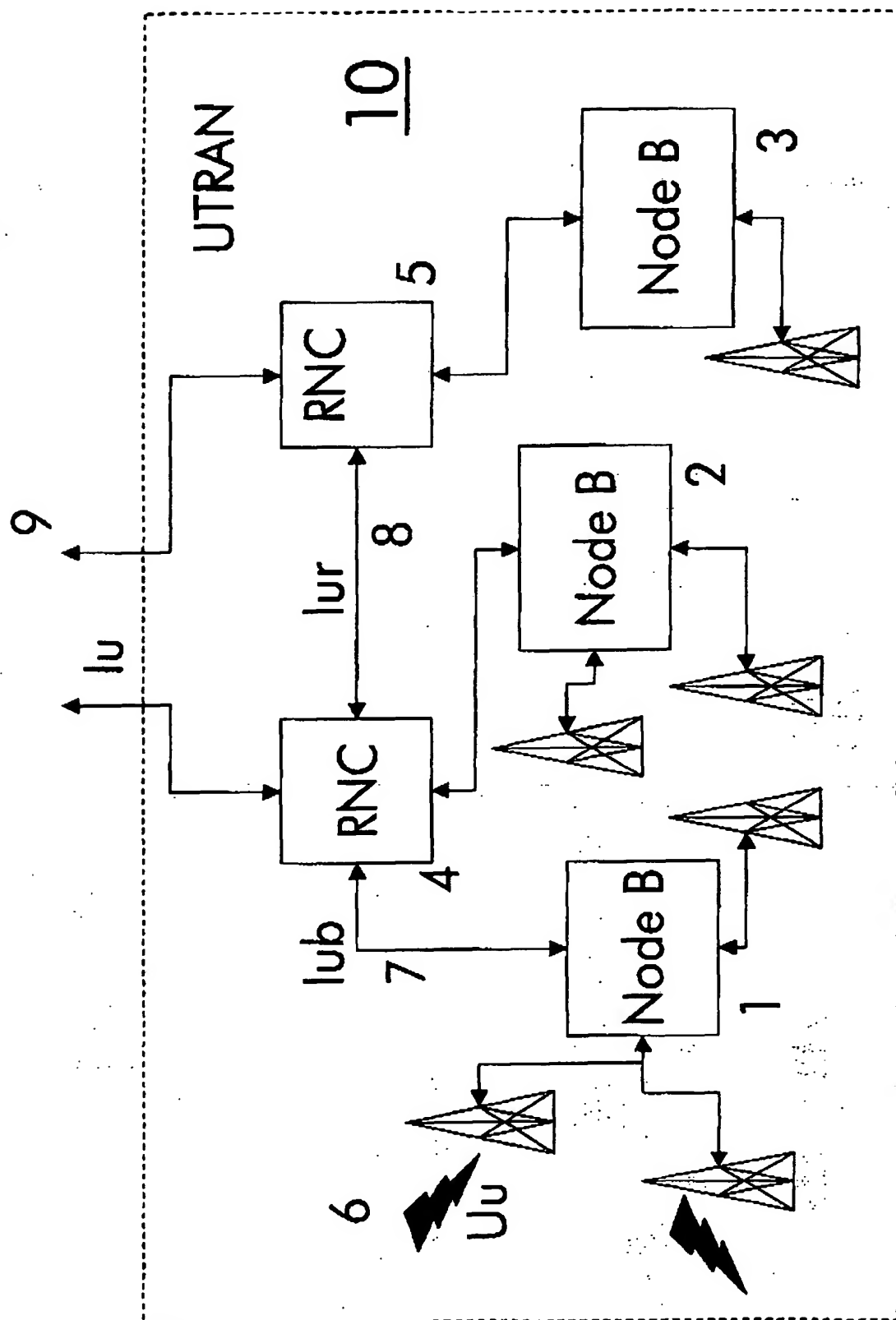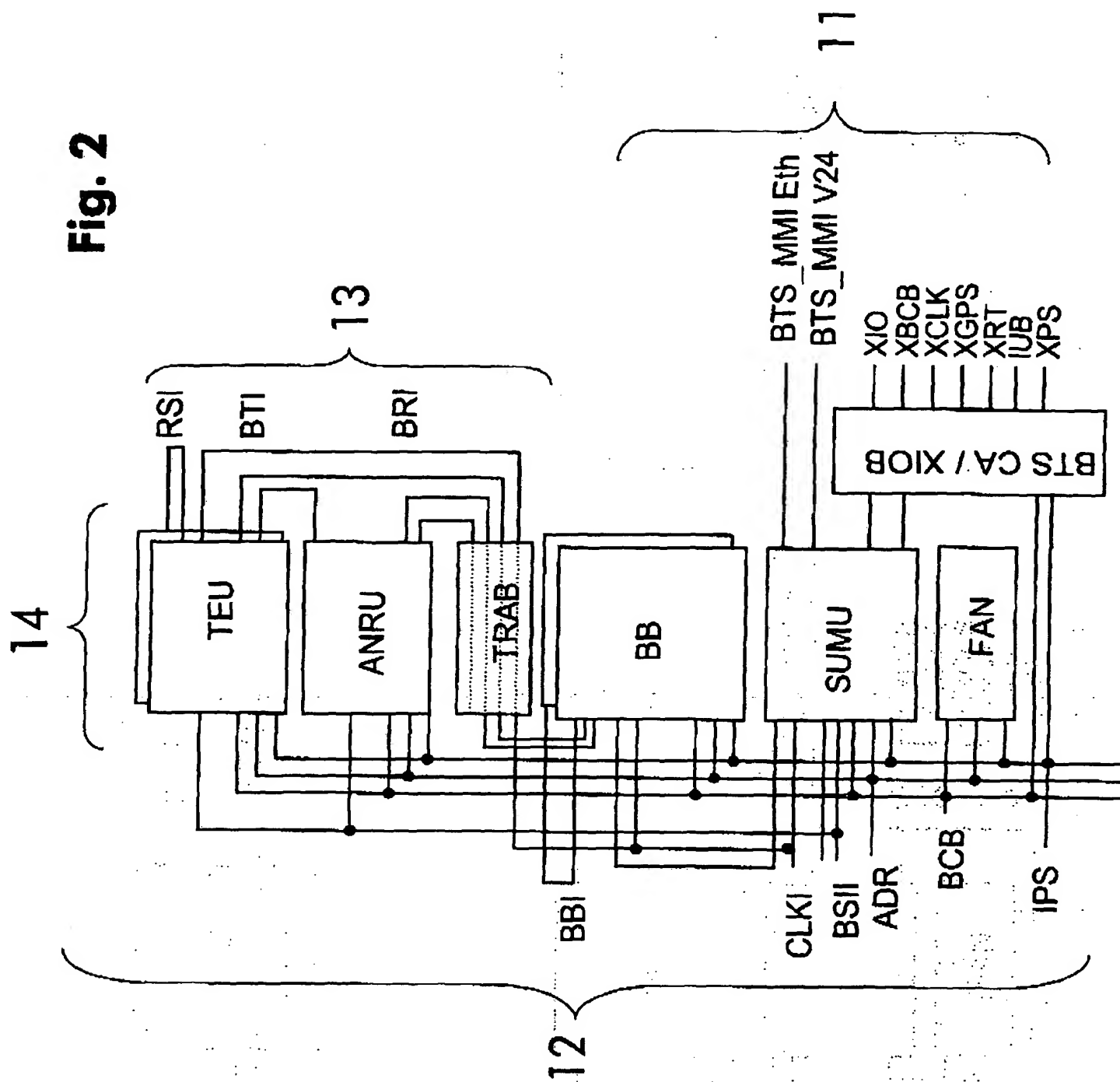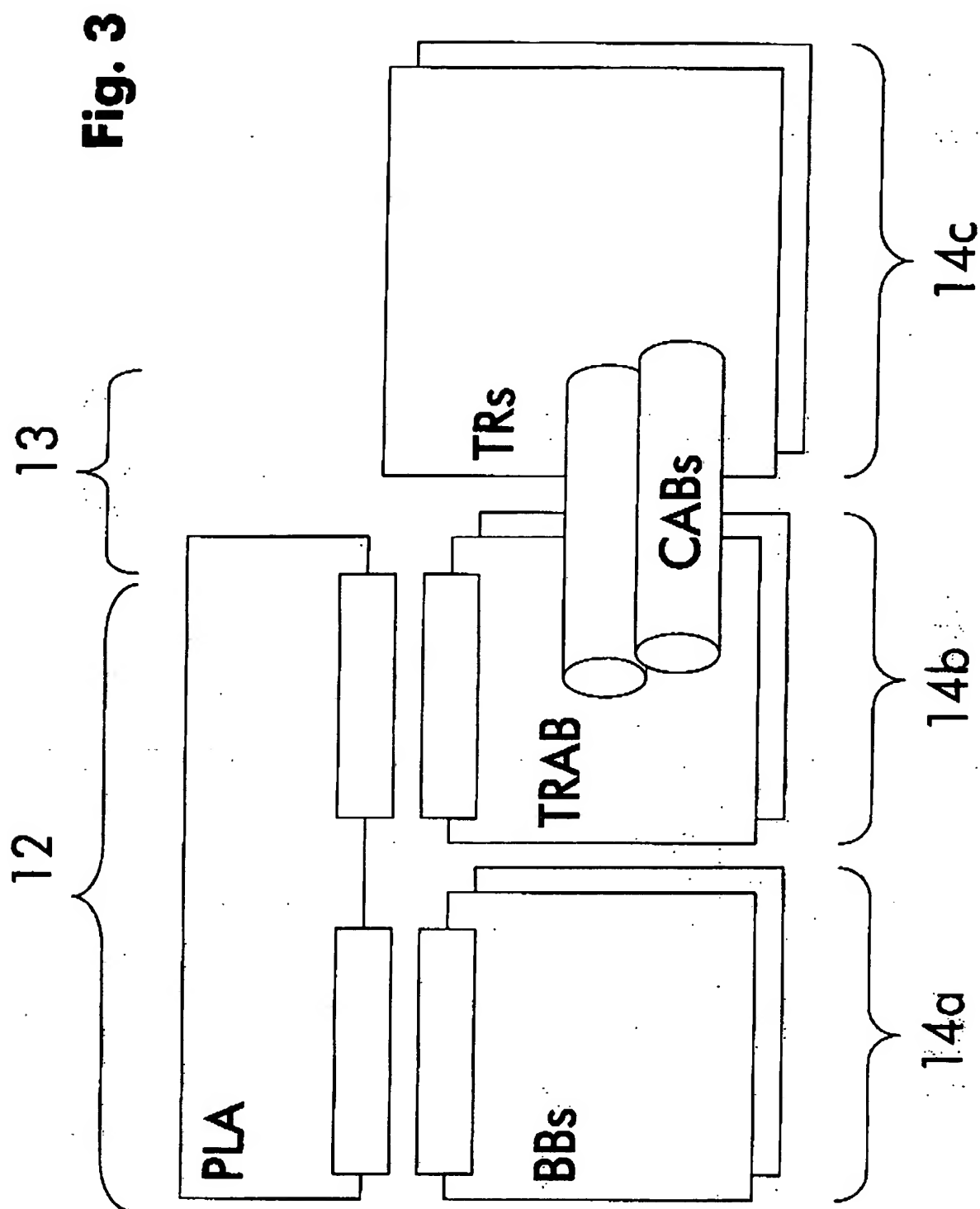20

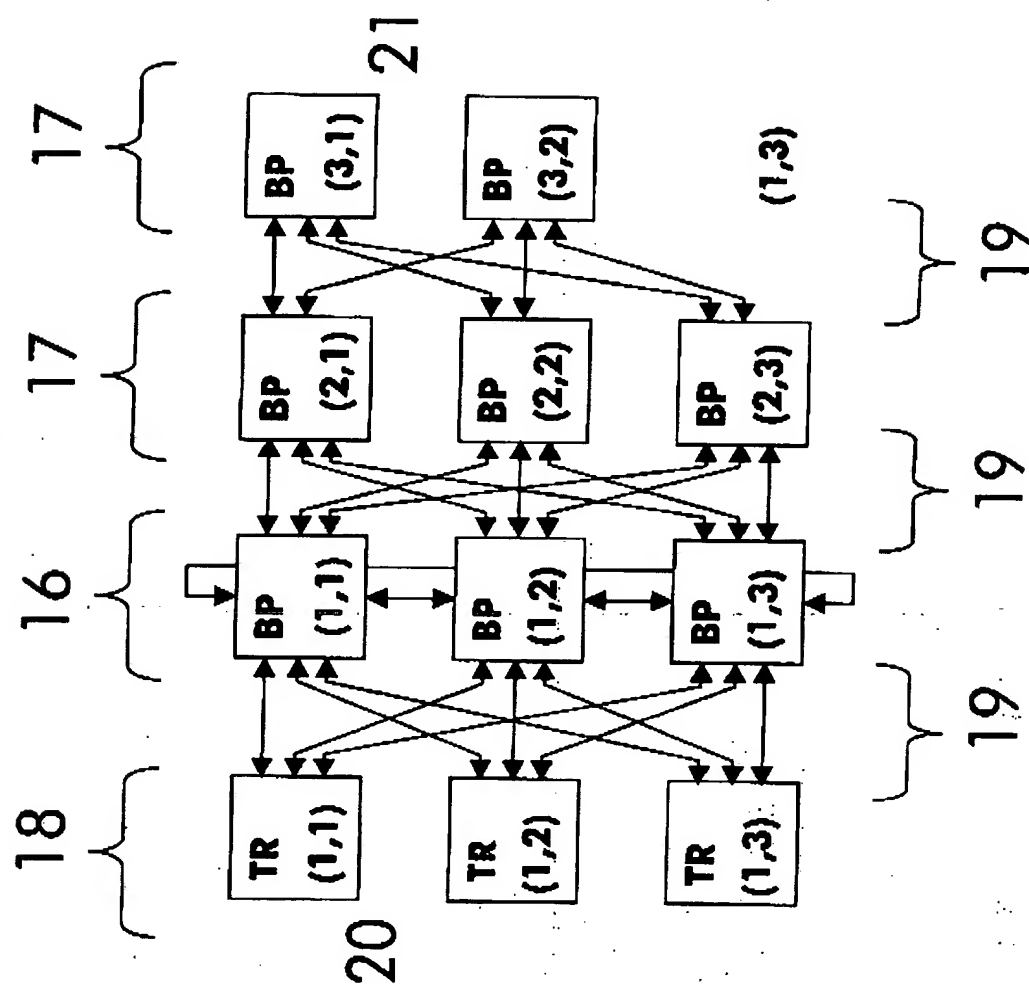(Figure 12)

Fig. 1
Prior Art

UTRAN

10

9

Iu

Iur

8

RNC

5

Node B

3

RNC

4

Node B

2

Iub

7

Node B

1

6

Uu

Fig. 2

11

13

14

RSI

BTI

BRI

BTS_MMI Eth
BTS_MMI V24

XIO
XBCB
XCLK
XGPS
XRT
IUB
XPS

TEU

ANRU

TRAB

BB

SUMU

FAN

BTS CA / XIOB

BBI

CLKI
BSII
ADR

BCB

IPS

12

Fig. 3

PLA

BBs

TRAB

CABs

TRs

12

13

14a

14b

14c

Fig. 4

Pri r Art
Fig 5

25

BBX BBX BBX BBX BBX BBX BBX BBX BBX

23

24

TRX   TRX   TRX

26

22

BP(n+1,*)

29

OUT

34

39

33

BBPs

37

IN

BP(n,m)

31

RAE

RAE

32

BP(n-1,*)
or
TR(1,*)

27

IN

35

38

36

OUT

28

BP(n-1,*)
or
TR(1,*)

BP(n+1,*)

30
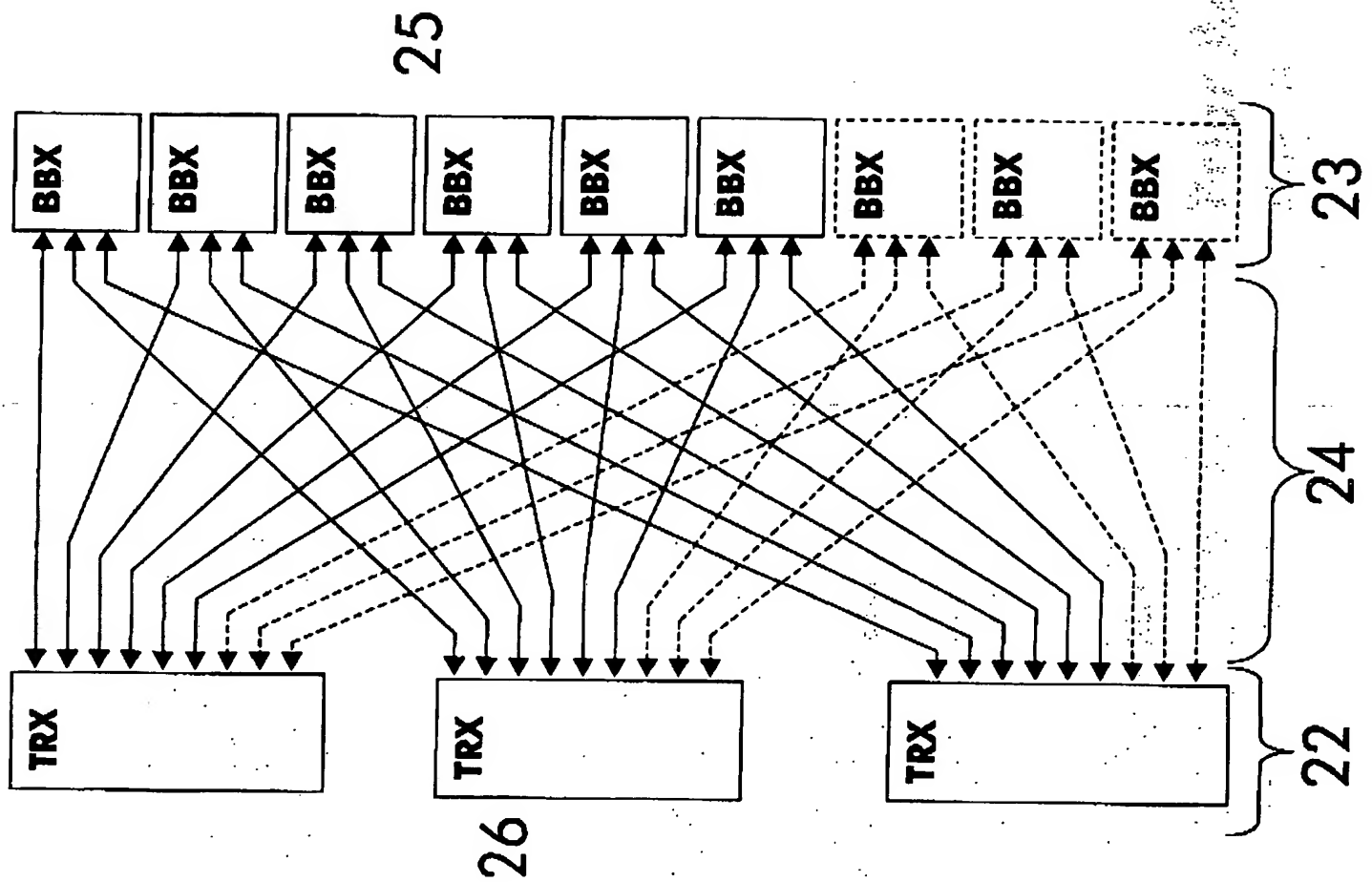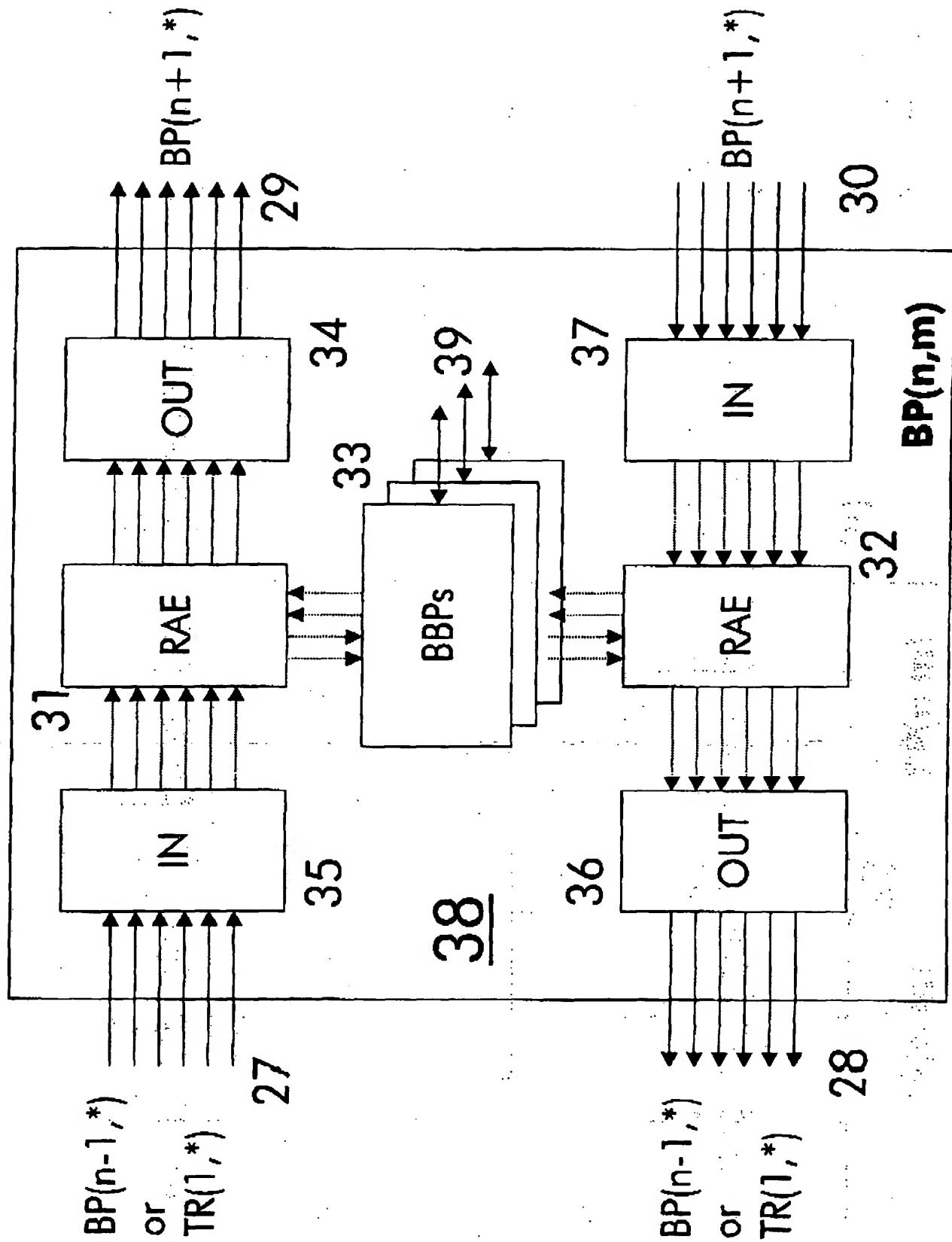
Fig 6
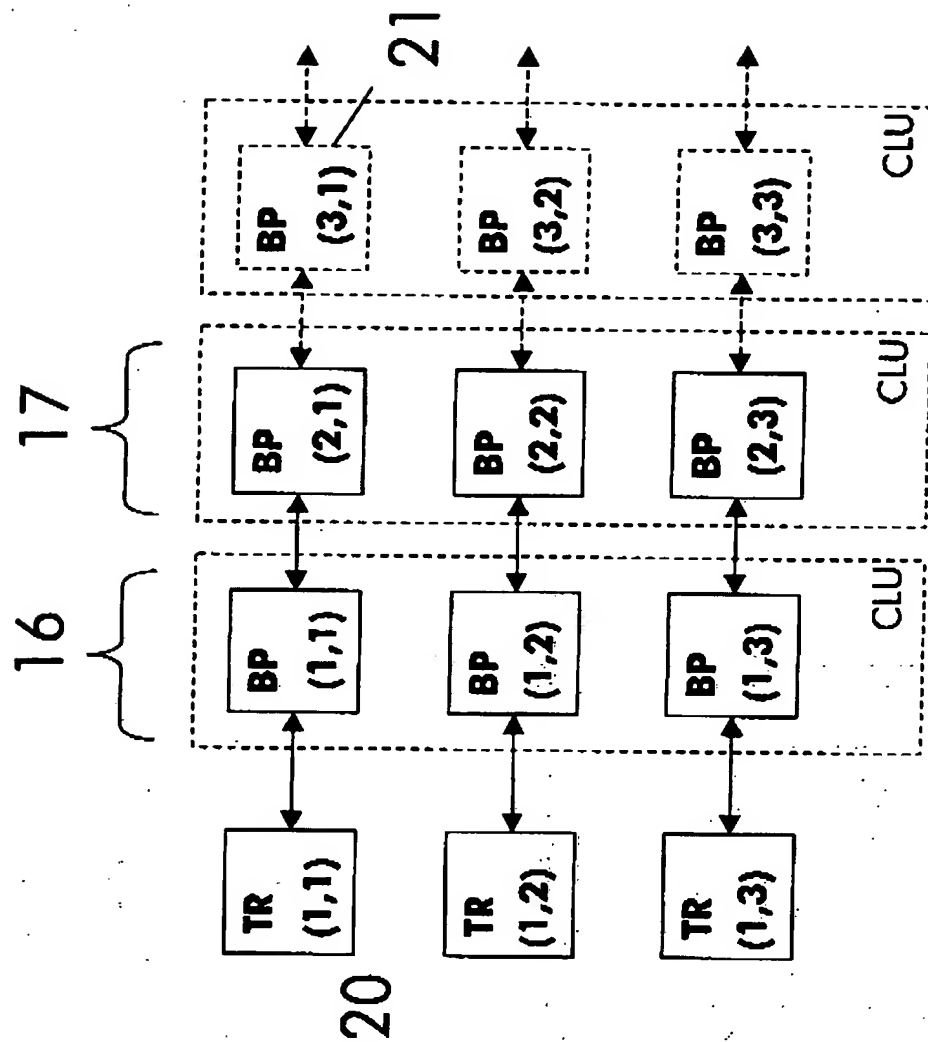
Fig 7

Fig 10

Fig 11

Fig 12

US 1076107602P1
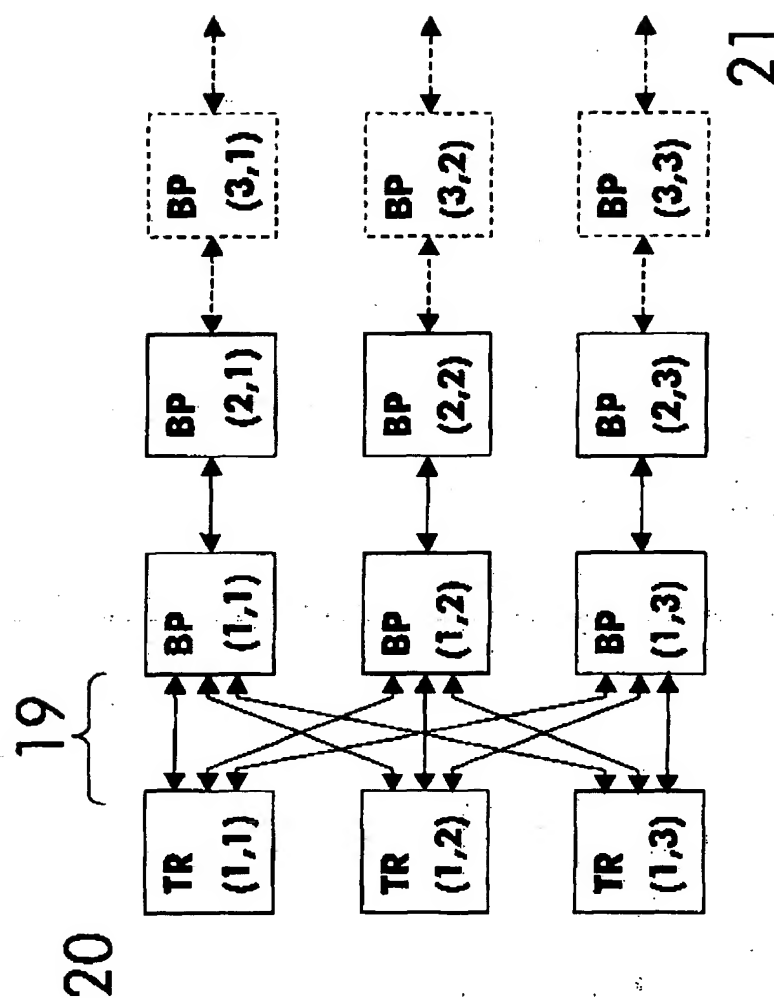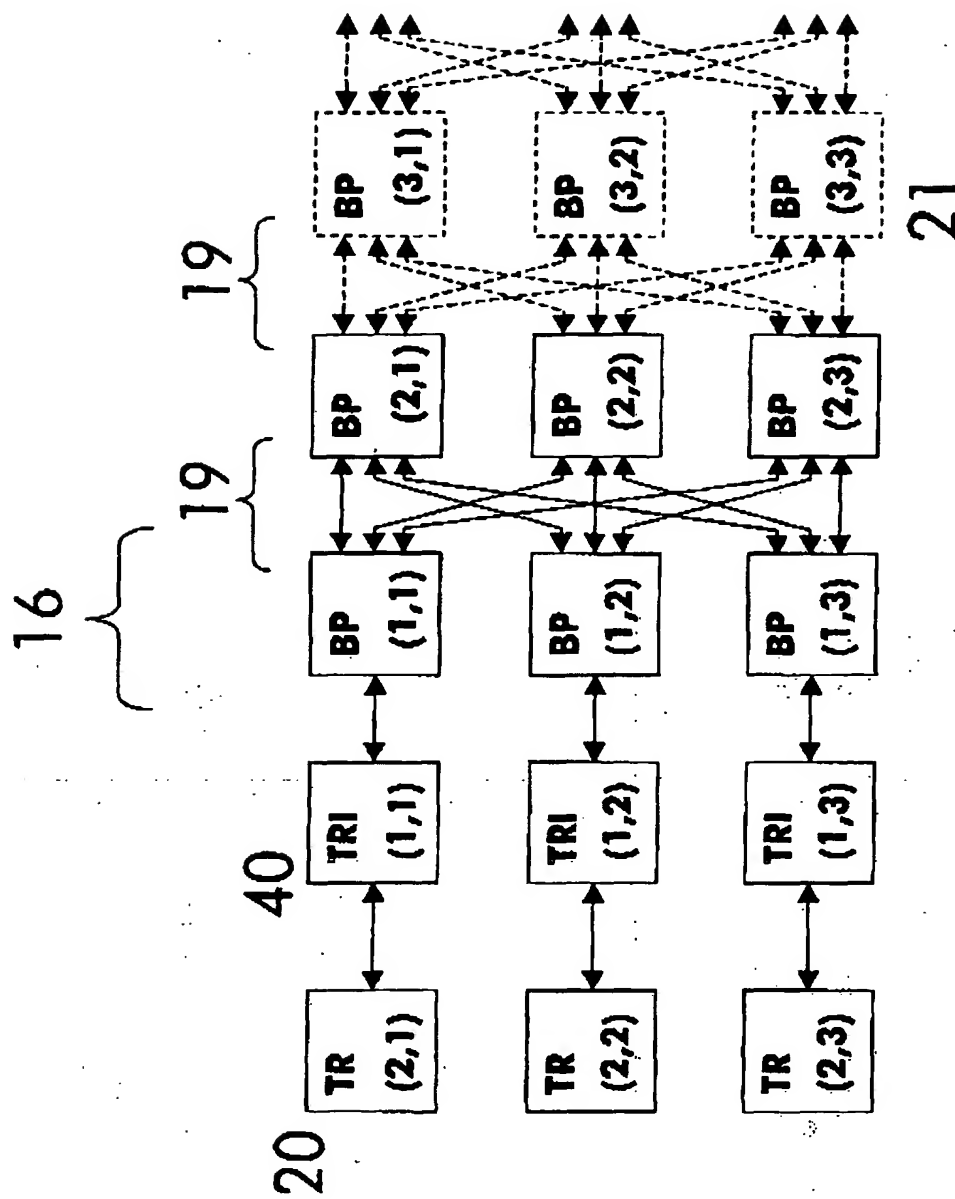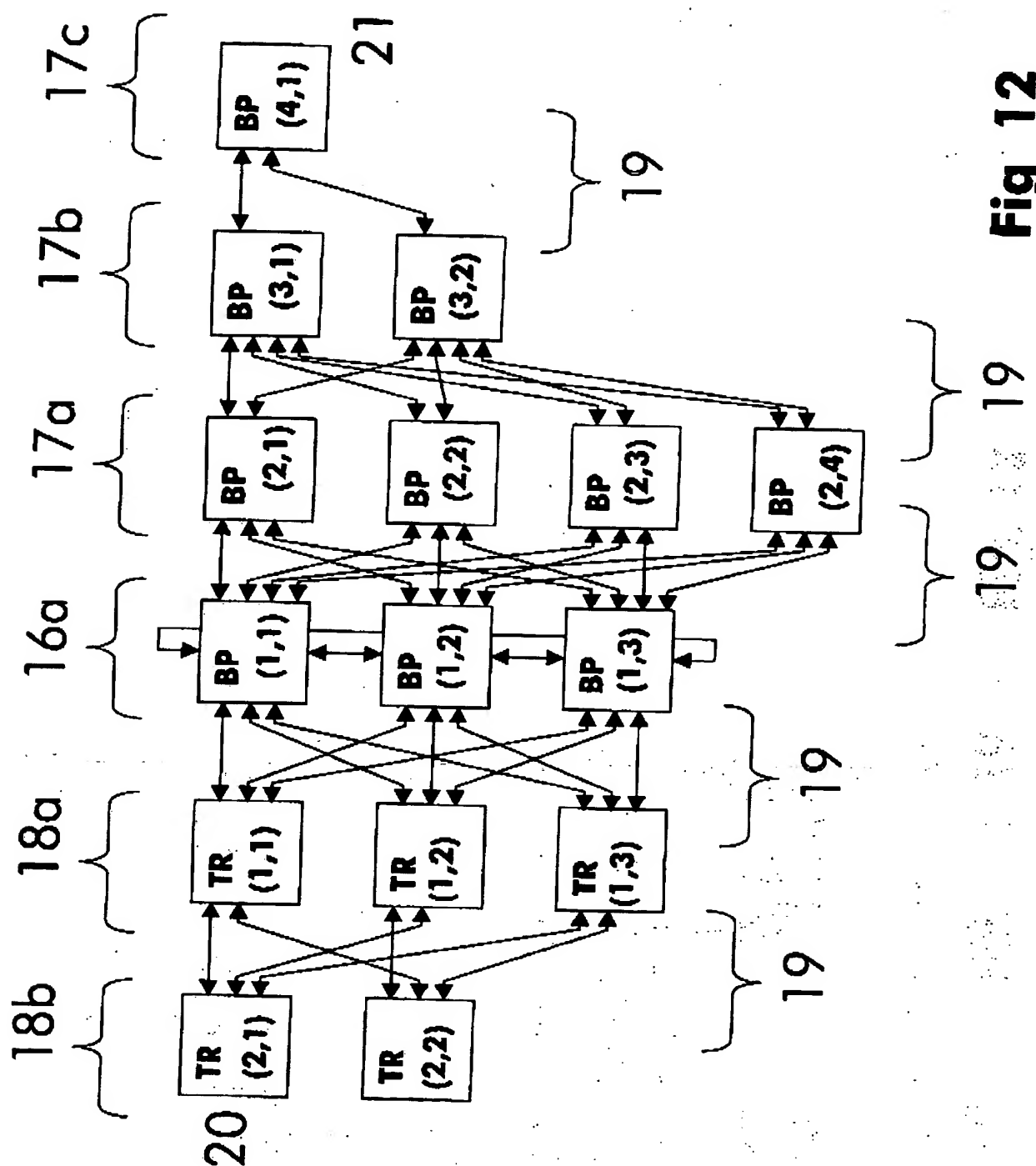

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